Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

IoT Based Detection and Alerting of Hazardous Gas Detection for the welfare of Sewer Labourers

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In contemporary times, manual labour continues to be employed for the maintenance of sewage systems because there are insufficient safety precautions for workers. Gas sensors continuously measure and modify the quantities of harmful compounds, like carbon monoxide and methane, to ensure that they adhere to safety regulations. But without safety gear, employees are vulnerable, so a prompt detection and alerting system is required. Specifically, we are working on developing a device that can detect dangerous chemicals such as ammonia, carbon monoxide, methane, and hydrogen sulphide, in addition to measuring the temperature inside manholes. In order to guarantee the worker's fast rescue, the system immediately sounds a buzzer and sends an alarm message via a GSM module when it detects irregularities.

Keywords: Sewage system, GSM Module, Alerting system, Gas detection and Real-time monitoring system.

1. Introduction

Although sewage systems are essential for managing waste and maintaining public health, the environment and worker safety are at risk from the dangerous gases they contain. Microbial activity and chemical reactions result in the buildup of methane, hydrogen sulphide, and carbon monoxide[7][23]. These gases endanger the health of workers not only in the short term by causing symptoms like suffocation and disorientation, but also in the long run by causing skin infections and lung cancer. There is a significant chance of dying from prolonged exposure [2][4].

Hazardous gases must be monitored closely to identify abnormal concentrations and take immediate action to protect public health. They are necessary in certain sectors, but they can have detrimental effects. Although efficient, current systems are not portable and can be expensive and difficult to set up [19]. This has led to the development of an embedded system that uses a microcontroller to detect potentially dangerous gas spills. The proposed system describes how to monitor dangerous gases like methane, ammonia, carbon monoxide, and hydrogen sulphide. Should these gases rise above the standard amounts, an immediate alarm is set off, and the authorised user receives an SMS alert. This quick reaction helps information spread more quickly in emergency situations [10]. These gases are dangerous to workers in two ways. They may, in the short run, result in acute health issues such as dysphagia, vertigo, and confusion. Even worse outcomes can result from prolonged exposure, as it raises the possibility of skin infections, lung cancer, and even death [17][21][25].

Furthermore, the device makes it easier to detect gas concentrations in the air in real-time. Owing to its automated structure, this approach guarantees prompt information delivery, averting possible hazards to human life. The system provides inexpensive, real-time airborne gas concentration monitoring that is simple to integrate into drainage systems. By addressing health issues and improving general safety in sewage maintenance, protects both the environment and the workers [15].

2. Related Work

The work focuses on monitoring poisonous gases in sewage environments using IoT devices and platforms. To provide smart solutions to monitor sewage gases in real-time, alerting workers remotely when threshold levels are exceeded to ensure their safety. Using various sensors to identify gases including carbon monoxide (CO), methane (CH_4), and hydrogen sulphide (H_2S) and integrating IoT platforms like Thing Speak for data analysis and remote access [1]. The author describes their efforts in maintaining the sewage systems. Hazardous gases, including CH_4, CO, and H_2S, are generated whenever organic waste, such as leftover food and wet waste, accumulates on a regular basis. In order to stop worker gas poisoning, they suggested identifying these dangerous chemicals in sewage systems [5][14].

Developed a device to detect and warn individuals about the existence of dangerous gases such as methane and propane, which are combustible and can blow up in a small space. Three sensors are included in the system: one each for methane, hydrogen, and liquefied petroleum gas (LPG). There is a set point for every sensor. These sensors act as switches, sending data to an Arduino controller for the study of the gas levels. Tests show that the gadget can detect gas at up to 50, 30, and 30-inch maximum distances for LPG, methane, and hydrogen, respectively [3]. The work implements a portable gas leak-detecting safety gadget, primarily meant to protect homes where natural gas and LPG-powered equipment and heaters present a risk. The receiving unit and the detection and transmission unit are the two primary elements that make up the system. The detection and transmission unit identifies using a unique detecting device to measure variations in gas levels and checks if the change exceeds a predetermined threshold [16].

The study conducted by [18] compares three online sensors that are currently on the market and can detect hydrogen sulphide (H_2S) in the liquid phase in sewer systems. A Clark-type electrochemical microsensor's design and principles are adapted for the third sensor, while UV spectrophotometry serves as the basis for the other two. In real-world sewer circumstances, the study assesses the sensors' sensitivity, accuracy, and dependability. Work [6] detects CO and CO_2 levels using MQ-7 and MQ-135 sensors that are linked to an ESP32 microprocessor, respectively. A smartphone app called Blynk allows for real-time monitoring of the readings in addition to their display on an LCD.

The study on comparing and evaluating the MQ-6 and MQ-2 gas sensors to identify leaks of liquefied petroleum gas was presented within [20]. LPG leaks endanger both human life and property and are a major source of fire hazards. In the experimental setup, the response time and returned parts per million or ppm, values of both sensors were tested with LPG gas. Both sensors responded to the LPG gas at various distances in a matter of seconds, which is comparable to their reaction times. The work on developing and putting into practice a sensor-oriented system to identify waste gases, namely ammonia (NH3), hydrogen sulphide (H2S), and methane (CH4) was proposed in [8]. A sensor-oriented waste gas detection system that can access data from the web server and accurately determine whether waste gases are present or not.

Work describes how to use remote sensing to monitor a person's temperature and pulse rate (BPM), among other human health metrics. Additionally, in the event of an emergency, the system will recommend potential actions that, if followed, could improve one's chances of surviving [9][26].

Developed a "Wireless Sensor Network (WSN)"-based "Advanced Fire Alarm" system to improve industrial safety and safeguard people's lives and property. In order to anticipate any threats, the system automatically detects changes in temperature and gas levels. It is made up of "Child Sensor Nodes" and a "Master Control Panel," where the master logs data from various devices into a webpage and regulates it. Sensors such as the ESP8266 Wi-Fi module, 100 KΩ NTC thermocouple, and MQ-2 sensor are included in each device. Data is collected and updated by the system, and users may keep an eye on it via an IoT panel. The 'Message Queuing Telemetry Transport (MQTT)' broker is employed to collect temperature and gas leakage data. This technology simplifies data sharing between devices and makes the system easier to use [22].

Designed a smart system that can detect gas spills as well as fires by using an Arduino UNO microcontroller, gas and fire sensors, and actuators like fans and buzzers. Upon detection of a gas leak, the system notifies users using a mobile app and SMS. It can also use water to douse fires and automatically turn on the ventilation. The objectives of this system are to decrease environmental harm, increase safety, and lower fatality rates. It covers the following five primary issues: water pumping, alert notifications, auto ventilation, gas leak detection, and fire detection. This smart system responds to emergencies in a way that minimises loss of life and property by using sensors, alarms, and communication modules to safeguard homes against gas leaks and fires.

The construction of an Arduino-based smart house warning system is shown [12], which makes use of GSM for communication, actuators (such as buzzers, relays, water valves, fans, and light bulbs), and sensors (such as DHT22, MQ2, and cameras). The system notifies users by SMS, emails with photographs, and other means when it detects fire, gas leaks, and incursions with efficiency. In addition, it is capable of putting out fires and lowering gas concentrations. Systems like these are essential for home security since they stop mishaps and theft. The study describes the design and implementation process as well as the significance of these systems.

The application of cutting-edge technology in the automobile sector has resulted in the creation of smart cars meant to elevate societal standards. Still, more advancements are required to make these cars more intelligent at controlling pollutants in the environment. Despite government attempts, air pollution is still getting worse, due in part to industrial emissions. Solutions for keeping an eye on and managing environmental contamination are available in the literature. The study highlights the need for an IOT-based embedded system that can monitor and manage air pollution worldwide. An IoT-based prototype embedded system with actuators and sensors centred around a Raspberry Pi board has been created. The system has a web page for remote gas level monitoring and is created using standard libraries in Python [13][24].

3. Proposed Methodology

The proposed system presents an approach to monitor the hazardous discharge of gaseous contaminants. Fig. 1 represents the block diagram of hazardous gas detection in sewage systems, which consists of an Arduino UNO, a GSM module, a DHT11, an MQ-135 sensor, and an LCD. The system is designed to monitor the levels of hazardous gases within drainage systems or manholes, which include ammonia, carbon monoxide, and methane. It determines the concentrations of various gases using gas sensors such as MQ-4, and MQ135. A microcontroller unit processes the gathered data and then shows the outcomes on an LCD display. When the level of harmful gases exceeds preset thresholds, a notification is transmitted to the authorised person.

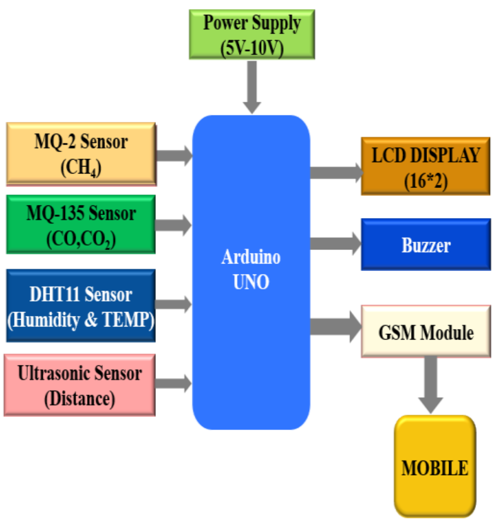

Fig. 1. Block Diagram of proposed system

The details of hardware components are listed below:

- Arduino UNO:

One well-liked microcontroller board for making electronic projects is the Arduino Uno. Through its input pins, it can be powered with 7–12V, however it runs at 5V. With fourteen digital input/output pins and six analogue input pins, it enables flexible connections to switches, sensors, and other parts. At its core, the ATmega328P microprocessor operates at a clock speed of 16 MHz and consists of 32 KB of flash memory for programme storage. The board has many LEDs for visual feedback, a reset button, and a USB port for programming and communication. Prototyping and learning electronics are popular uses for the Arduino Uno because of its small size and intuitive design.

- GSM module:

It is a small electrical device that is used to help devices or systems communicate with one another via the GSM network. These modules are frequently utilised in many different applications, including embedded systems, Internet of Things (IoT) devices, and mobile phones. Voice calls, SMS messaging, and data transmission over the GSM network are all made possible using GSM modules.

- DHT11 Sensor:

The DHT11 measures humidity and temperature using the capacitive sensing technique. For temperature and humidity, the sensor has a thermistor and a humidity-sensitive resistor. With a resolution of ±2°C, it measures temperature between 0 and 50°C, and with a precision of ±5%, it measures humidity between 20% and 80%.

- Ultrasonic Sensor:

Ultrasonic sensors are gadgets that detect objects or measure distance using ultrasonic vibrations. Ultrasonic pulses are usually emitted, and the duration between the waves' reflection off an object and return is measured to determine how they function. Frequency is a crucial parameter that impacts the accuracy and resolution of ultrasonic sensors. It typically falls between 20 kHz and 200 kHz.

- MQ-4 gas sensor:

A typical gas sensor used to identify combustible gases such as propane and methane is the MQ-4 sensor. The sensor generates an analogue voltage output that is proportionate to the concentration of gas, based on the principle that changes in the conductivity of a tin dioxide semiconductor when exposed to gases. It is frequently used in industrial safety applications, gas leak detection systems, and other projects that require combustible gas monitoring.

- MQ-135 gas sensor:

To identify gases in the air, including carbon dioxide, ammonia, methane, benzene, and volatile organic compounds, the MQ-135 sensor is extensively utilised. It adjusts resistance in response to varying gas concentrations by using a semiconductor-based gas-sensitive material.

- LCD Display:

LCD is a flat-panel display technology found in a variety of electronic products. LCDs are widely used in gadgets like computer monitors, televisions, and smartphones because of their thin and light construction.

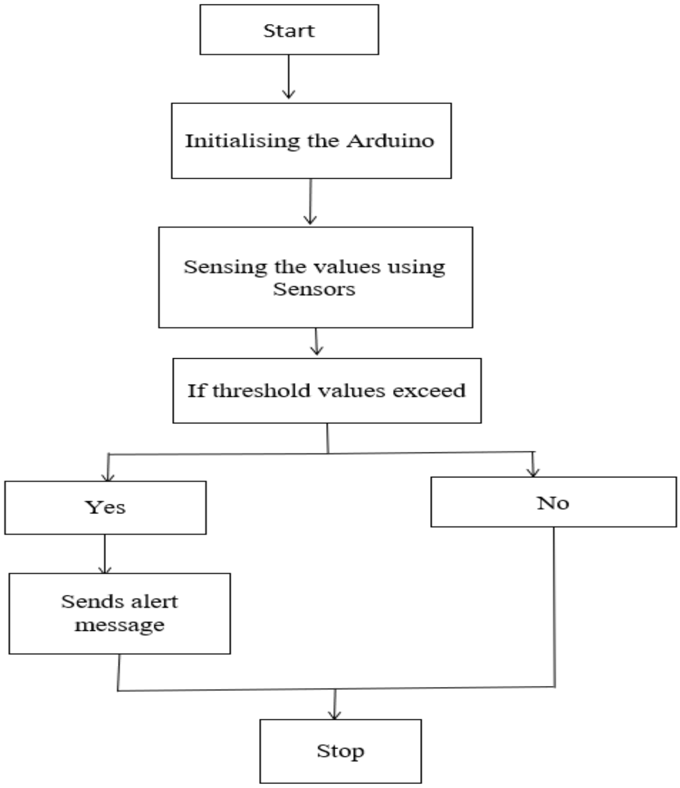

Fig 2. Flow Chart of the Proposed Model

The suggested model's flow chart is displayed in Fig. 2. This model was demonstrated in a real-world setting using a portable electronic device that was placed into the sewage system. It uses an array of integrated gas sensors to display the concentrations of toxic gases on various levels. The gas concentration is displayed on an LCD display via an Arduino equipped with an ATMEGA328P microcontroller. If the value exceeds the specified value, a buzzer module notifies the worker and alerts them by sending a notification message to the authorised person.

When the gadget is first powered on, the Arduino UNO receives data from the gas sensors, which measure the gases in the air. After that, the Arduino compares these numbers with the threshold and displays them on the LCD. A registered phone receives an SMS alert stating, "Harmful gases are detected," when the amount of gases is greater than the threshold value. Fig. 3 depicts the schematic representation of the proposed system.

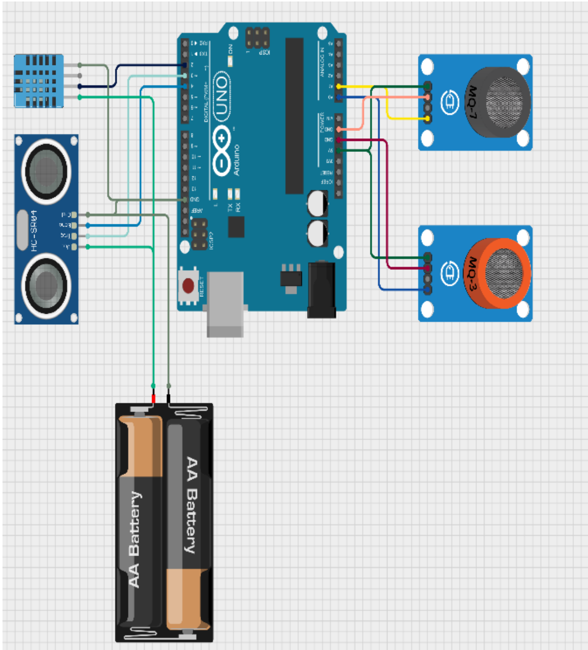

Fig. 3. Schematic representation

4. Results

The implementation model, Fig.4, is intended to use a prototype model to analyze the sewage system environment in real time. The main goal is to monitor which gases are in the sewage system and how much of each one there is, expressed in parts per million (ppm). The detection of dangerous gases like methane, carbon monoxide, carbon dioxide, and ammonia is the model's primary objective. Gas sensors, especially the MQ-135 and MQ-4 sensors, are used to accomplish the detection. The sewage worker is not permitted to enter the sewage system if the level of hazardous gas is higher. The sewage worker is permitted to enter the system if the gas concentration is lower. Depending on their degrees of concentration, workers can secure their safety by going through the required safety procedures before approaching the manhole.

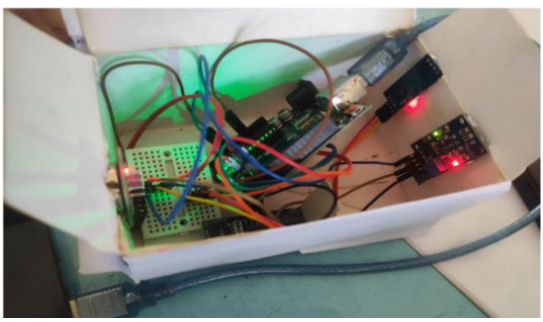

Fig. 4. Implementation Model

The model performs two actions in response to the gas sensors detecting the presence of any of the designated hazardous gases. Initially, it notifies the supervisor via a warning message that hazardous gases are present. Secondly, it sets off a buzzer to sound an alert. These comprise the detection of water level, humidity, and temperature. Utilizing a combination of gas sensors to identify potentially dangerous gases and an ultrasonic sensor

to track temperature, humidity, and water level, the model offers important environmental information about the sewage system, assisting in maintaining safe and effective operation.

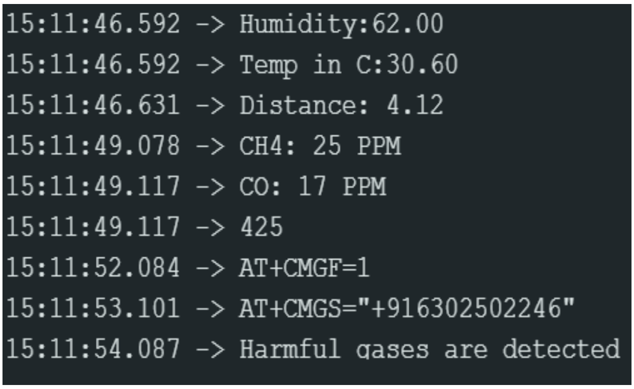

Fig. 5. Gases Concentration

Fig. 6. Output of the model

Experimental Values:

The experimental values of the several gases that were collected from the sewage system are displayed in the table below.

Table 1. Experimental values of sewer gases

Sewer Gas found	**Threshold value of PPM**	**Experimental Values**
Methane	1000	25
Carbon monoxide	50 PPM or more	17
Ammonia	50	45

5. Conclusion

There are several benefits to the designed hardware system for sewage system gas concentration analysis, including cost effectiveness, user-friendliness, and ease of handling for workers. Sewerage cleaning techniques should be improved in developing nations like India to reduce the danger to the lives of cleaning workers. The device's main uses include detecting harmful gases, alerting users, and lowering gas concentration levels to create comfortable working environments. When the prevalent gases in the sewage manhole surpass their threshold limitations, the GSM module can notify the supervisor of the test results.

The suggested approach will aid in sewage workers' life protection against dangerous diseases such as typhoid and hepatitis. Many sewer workers lost their lives while performing their duties, according to recent news updates, after inhaling highly concentrated hazardous gases that could have major health consequences. The lives of sewage workers will be greatly impacted by this IOT-based, sophisticated technological system. More sensors for additional harmful gases such as hydrogen sulphide (H2S), methane(CH_4), and sulphur dioxide, can be added to the design to further enhance it. Additionally, this design can support a worthwhile social purpose by adding new features like tracking, location services, and an updated alert system. Thus, the department of health and sanitation will be able to benefit from this project.

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